IMAGE READING SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image reading system capable of black-and-white and color image reading in two modes, and adapted for use in a facsimile or a scanner.

Related Background Art

For reading a color original, there is already known a color image sensor with light source switching, in which light emitting diodes (LED) are provided for emitting lights of three primary colors of R(red), G(green) and B(blue) and a signal is obtained from a photosensor by irradiating each position of the original with each of the R, G and B lights whereby a color signal is obtained corresponding to the color original.

The drive of such light source-switched color image sensor is controlled by an image sensor driving circuit 101 as shown in Fig. 35, wherein provided are a light source-switched color image sensor unit 200, a main controller 102 for controlling the drive thereof, a control signal generating circuit 103 for generating control signals XSH, MCLK in response to a control signal CNT from the main controller 102, an LED control unit 104 for generating signals, ΦR, ΦG, ΦB for

controlling the turning-on of the R, G, B LEDs in response to the control signals CNT and XSH, and a sensor array control unit 105 for generating signals SP, CLK for controlling the drive of a sensor array in response to the control signal XSH, MCLK.

In such image sensor driving circuit, the main controller 102 sends the control signal CNT matching the reading mode to the control signal generation circuit 103 and the LED control circuit 104, thereby controlling the turning-on of the R, G and B LEDs and driving the sensor array according to the reading mode.

In the color original reading mode, the image sensor drive circuit 101 supplies the light source-switched image sensor unit 200 with the control signals ΦR, ΦG, ΦB, SP and CLK as shown in Fig. 36, to effect the image reading in the following manner.

At first the signal ΦR turns on the R LED only, and the sensor array is activated by the start pulse SP and the clock pulse CLK to accumulate R signals in the pixels of the sensor array. After the lapse of an R signal accumulation time t_{ron12}, the R LED are turned off by the signal ΦR. Then the G LED are turned on by the signal ΦG and the start pulse SP is entered again, whereupon the R signals already accumulated in the pixels of the sensor array are simultaneously transferred to analog memories on the sensor array and then are output to the exterior pixel by pixel.

After the same time, G signals are accumulated in the pixels of the sensor array. After the lapse of a G signal accumulation time t_{gon12}, the G LED are turned off by the signal ΦG. Then B LED are turned on by the signal ΦB and the start pulse SP is entered again, whereby the G signals already accumulated in the pixels of the sensor array are simultaneously transferred to analog memories on the sensor array and then are output to the exterior pixel by pixel.

At the same time, B signals are accumulated in the pixels of the sensor array. After the lapse of a B signal accumulation time t_{bon12}, the B LED are turned off by the signal ΦB. Then the R LED are turned on by the signal ΦR and the start pulse SP is entered again, whereby the B signals already accumulated in the pixels of the sensor array are simultaneously transferred to analog memories on the sensor array and then are output to the exterior pixel by pixel.

In this state the image sensor unit 200 has been moved to a next reading line, and similar operation are repeated for obtaining R, G and B signals. The entire color image is read by repeating the above-explained sequence by moving the image sensor unit 200 line by line in the subscanning direction.

In Fig. 36, the turn-on time t_{ron12}, t_{gon12}, t_{bon12} of the R, G, B LED and the output periods t_{r12}, t_{g12}, t_{b12} of the R, G, B sensors are selected as $t_{ron12} = t_{gon12} = t_{bon12} =$

$t_{r12} = t_{g12} = t_{b12}$. This is achieved by adjusting the forward currents of the R, G, B LED of the color image sensor units in such a manner that predetermined sensor output levels are obtained for the R, G and B signals for an LED turn-on time same as the sensor output time for outputting the signals of all pixels.

Then, in the black-and-white original reading mode, the image sensor drive circuit 101 supplies the light source-switched image sensor unit 200 with the control signals ΦR, ΦG, ΦB, SP and CLK as shown in Fig. 37, wherein the turn-on time t_{ron13}, t_{gon13}, t_{bon13} of the R, G, B LED and the black-and-white output period t_{w13} are selected as $t_{ron13} = t_{gon13} = t_{bon13} = t_{w13}$ and $t_{ron\ 13} \neq t_{ron12}$. In this mode, the turn-on duty ratio of the LED is different from that in the color image reading because the R, G and B LED are simultaneously turned on for reading each line. Also in case of color image reading, the illuminating light intensity is so adjusted as to provide a predetermined sensor output when only one of the R, G and B LED is turned on. Because of these facts, the forward currents and the turn-on times of the R, G, B LEDs in reading the black-and-white original have to be made different from those in the color image reading mode.

The reading of the black-and-white original is executed in the following manner with the control signals shown in Fig. 37. At first all the LEDs of R,

G and B colors are simultaneously turned on by the signals ΦR, ΦG, ΦB, and the sensor array is activated by the start pulse SP and the clock pulse CLK, whereby W signals corresponding to the black-and-white image are accumulated in the pixels of the sensor array. After the image reading of a line of the original, the image sensor unit 200 is moved to a next reading line and the start pulse SP is entered again, whereby the W signals already accumulated in the pixels of the sensor array are simultaneously transferred to the analog memories of the sensor array and then are output to the exterior in succession.

In this state, all the LEDs of R, G and B colors are turned on, whereby W signals of the next reading line are accumulated in the pixels of the sensor array. After the image reading of this line of the original, the image sensor unit 200 is moved to a further next reading line and the start pulse SP is entered again, whereby the W signal already accumulated in the pixels of the sensor array are simultaneously transferred to the analog memories of the sensor array and then are output to the exterior in succession. The black-and-white reading of the entire original is executed by repeating the above-explained sequence, with successive movement of the image sensor unit 200 by a line in the sub scanning direction.

As explained in the foregoing, such conventional

light source-switched color image sensor can not only read the color image by illuminating each reading line of the original by turning on the R, G and B LEDs in succession and obtaining the output of the line sensor, but also read the black-and-white image by simultaneously turning on such R, G and B LEDs and obtaining the output of the line sensor.

However, in case of the black-and-white image reading, since the R, G and B LEDs are simultaneously and continuously turned on, the system may become unreliable if these LEDs are turned on under the same conditions as those in the color image reading. For this reason, the reliability of the system is maintained for example by reducing the currents supplied to the LEDs at the black-and-white image reading in comparison with those in case of the color image reading, but such operation complicates the LED driving circuit and the signal processing circuit, thereby elevating the costs thereof.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an image reading system capable of color image reading and monochromatic image reading of high image quality, with a simple configuration.

Another object of the present invention is to provide a light source control device enabling image

reading with an appropriate light amount.

Still another object of the present invention is to prevent deterioration of the light source employed in the image reading, to prevent the lowering in the illumination intensity of the light source, and to extend the service life of the light source.

The above-mentioned objects can be attained, according to an embodiment of the present invention, by an image reading system comprising plural light sources of mutually different light emission wavelengths, reading means for reading the image illuminated by the plural light sources, thereby outputting image signals, and control means for effecting control, in causing the reading means to effect monochromatic image reading by turning on the plural light sources in succession, in such a manner that the turn-on period of at least one of the plural light sources becomes shorter than that in the color image reading.

There is also provided a light source control device for controlling the light sources to be used in an image reading device, comprising plural light sources of mutually different light emission wavelengths, and control means for effecting control, in case of monochromatic image reading by the image reading device, in such a manner that the plural light sources are turned on in succession, and that the turn-on period of at least one of the plural light sources

becomes shorter than that in the color image reading.

Also there is provided a memory medium storing a program for effecting control, in case of monochromatic reading, in such a manner that plural light sources of mutually different light emission wavelengths are turned on in succession, and that the turn-on period of at least one of the plural light sources becomes shorter than that in the color image reading.

In this manner it is rendered possible to achieve image reading with an appropriate light amount, without difference in the currents supplied to the light source, between the color reading and the monochromatic reading.

In another embodiment, there is provided an image reading system comprising plural light sources of mutually different light emission wavelengths, reading means for reading the image illuminated by the plural light source, thereby outputting image signals, and control means for effecting control in such a manner as to cause the reading means to effect the monochromatic image reading in a state in which at least one of the plural light sources is reduced in luminance in comparison with that in the color image reading and at least two light sources are turned on.

In another embodiment, there is also provided a light source control device for controlling light sources to be used in an image reading device,

comprising plural light sources of mutually different light emission wavelengths, and control means for effecting control, in case of monochromatic image reading with the plural light sources, in such a manner as to cause the image reading device to effect monochromatic image reading in a state in which at least one of the plural light sources is reduced in luminance in comparison with that in the color image reading and at least two light sources are turned on.

In another embodiment, there is also provided a memory medium storing a program for effecting control, in case of monochromatic image reading with plural light sources of mutually different light emission wavelengths, in such a manner as to effect monochromatic image reading in state in which luminance of the light source is reduced in comparison with that in the color image reading and at least two light sources are turned on.

In this manner it is rendered possible to prevent the lowering in the illumination intensity resulting from the deterioration of the light sources, and to extend the service lift of the light sources.

In still another embodiment, there is provided an image reading system comprising plural light sources of mutually different light emission wavelengths, reading means for reading the image illuminated by the plural light sources, thereby outputting image signals, and

control means for effecting control in such a manner as to cause the reading means to effect monochromatic image reading in a state in which the electric power lower supplied to at least one of the plural light sources is reduced in comparison with that in the color image reading and at least two light sources are turned on.

In still another embodiment, there is provided a light source control device for controlling light sources to be used in an image reading device, comprising plural light sources of mutually different light emission wavelengths, and control means for effecting control, in case of monochromatic image reading by the image reading, in such a manner as to reduce the electric power lower supplied to at least one of the plural light sources is reduced in comparison with that in the color image reading and at least two light sources are turned on.

In still another embodiment, there is also provided a memory medium storing a program for effecting in case of monochromatic image monochromatic reading with plural light sources of mutually different light emission wavelengths, in such a manner as to effect monochromatic image reading in a state in which the electric power supplied to at least one of the plural light source is reduced in comparison with that in the color image reading and at least two light

sources are turned on.

In this manner it is rendered possible to prevent the lowering in the illumination intensity resulting from the deterioration of the light sources, and to extend the service life of the light sources.

In still another embodiment, there is provided an image reading system comprising plural light sources of mutually different light emission wavelengths, reading means for reading the image illuminated by the plural light source in the unit of a line thereby outputting image signal, and control means effecting control, in case of monochromatic image reading by the reading means, in such a manner as to turn on, in each line, a fewer number of light sources than in the color image, among the plural light sources, and to change the light sources to be turned on in every line, wherein the light source is a light emitting element and further comprising a light guiding member for guiding the light emitted from the light emitting element for irradiating the image.

In still another embodiment, there is provided a light source control device for controlling light sources to be used in an image reading device, comprising plural light sources of mutually different light emission wavelengths, and control means effecting control, in case of monochromatic image reading by the image reading device, in such a manner as to turn on,

in each line, a fewer number of light sources than in the color image reading, among the plural light sources and to the light sources to be turned on in every line, wherein the light sources is a light emitting element and further comprising a light guiding member for guiding the light emitted from the light emitting element for irradiating the image.

In still another embodiment, there is also provided a memory medium storing a program for effecting monochromatic image reading by turning on, in each line, a fewer number of light sources than in the color image reading with plural light sources, and changing the light sources to be turned on in every line.

In this manner it is rendered possible to reduce the total turn-on time of each light source in monochromatic reading, to prevent the lowering in the illumination intensity resulting from the deterioration of the light sources and to extend the service life of the light sources.

Still other objects of the present invention, and the features thereof, will become fully apparent from the following description, which is to be taken in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an external perspective view of a light

source-switched color image sensor;

Fig. 2 is a cross-sectional view showing the internal structure of the light source-switched color image sensor;

Fig. 3 is a view showing a substrate on which a sensor array is mounted;

Fig. 4 is a lateral view of a light-guiding light source;

Fig. 5 is a cross-sectional view of the light-guiding light source;

Figs. 6A and 6B are views showing examples of arrangement of LED packages and LED chips on an LED substrate;

Fig. 7 is a block diagram of an image reading system;

Fig. 8 is a timing chart of the black-and-white image reading in a first embodiment;

Fig. 9 is a chart showing the relationship between the allowable forward current of LED and duty ratio thereof;

Fig. 10 is a chart showing the relationship between the forward current of LED and relative light intensity thereof;

Fig. 11 is a flow chart showing the image reading operation in the first embodiment;

Fig. 12 is a timing chart in the black-and-white image reading in a second embodiment;

Fig. 13 is a flow chart showing the image reading operation in a second embodiment;

Fig. 14 is an external perspective view of a color image sensor constituting a third embodiment;

Fig. 15 is a cross sectional view showing the internal structure of the color image sensor of the third embodiment;

Fig. 16 is a schematic view of a substrate on which a sensor array is mounted;

Fig. 17 is a cross sectional view of the substrate with the mounted sensor array;

Fig. 18 is a view showing an example of arrangement of the LED chips on the substrate;

Fig. 19 is a chart showing the distribution of the relative light intensity of LED chips;

Fig. 20 is a chart showing changes in turn-on time of the LED in the third embodiment;

Fig. 21 is a timing chart showing the LED turn-on time in the color image reading in the third embodiment;

Fig. 22 is a timing chart showing the LED turn-on time in the black-and-white image reading in the third embodiment;

Fig. 23 is a flow chart showing the image reading operation in the third embodiment;

Fig. 24 is a timing chart of the black-and-white image reading operation in a fourth embodiment;

Fig. 25 is a flow chart showing the image reading operation in the fourth embodiment;

Fig. 26 is a cross sectional view of an image sensor in a fifth embodiment;

Fig. 27 is a timing chart of the color image reading;

Fig. 28 is a timing chart of the fifth embodiment;

Fig. 29 is a flow chart showing the image reading operation in the fifth embodiment;

Fig. 30 is an across sectional view showing an image sensor constituting a sixth embodiment;

Fig. 31 is a timing chart of the sixth embodiment;

Fig. 32 is a flow chart showing the image reading operation in the sixth embodiment;

Fig. 33 is a timing chart of a seventh embodiment;

Fig. 34 is a flow chart showing the image reading operation in the seventh embodiment;

Fig. 35 is a block diagram of a driving circuit for a light source-switched color image sensor;

Fig. 36 is a timing chart showing the LED turn-on time in color image reading; and

Fig. 37 is a timing chart showing the LED turn-on time in black-and-white image reading.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1 and 2 are respectively an external perspective view and cross-sectional view, showing a

first embodiment of the light source-switched color image sensor of the present invention. The color image sensor is composed of a light source in which the lights of R, G and B colors from LEDs are introduced from an end face of a light guide member and are emitted from a lateral face thereof to uniformly illuminate the original image, a short-focus imaging element array and a sensor array consisting of a linear array of plural photosensor elements.

Such color image sensor 200 is provided with a transparent glass plate 21, mounted in an upper part of a frame 20, so as to be contacted with the original image. The light 12 emerging from a light-guiding light source 3 provided in the frame 20 is reflected by the original image, maintained in contact with the upper face of the transparent glass plate 21, and, inside the frame 20, there are also provided an optical system 29 for receiving the reflected light 13 from the original image surface to be read and a sensor array 1 provided on a substrate 19 corresponding to such optical system 29. The above-mentioned optical system 29 is composed of a short-focus imaging element array, such as Celfoc lens array (trade name of Nippon Plate Glass Co.).

The sensor array 1 is so-called multi-chip sensor array, consisting of a linear array of plural line sensors 2-1, 2-2, ... , 2-15 on the substrate 19 as

shown in Fig. 3, and the entire sensor array 1 is covered with a protective film 26. The substrate 19, provided with such sensor array 1, is supported by a base plate 25, engaging with the frame 20, and is connected through a flexible cable 28 to a flexible circuit board 23, which is provided thereon with a connector 22 for input/output of power supply and control signals and is mounted on the frame 20.

Figs. 4 and 5 are respectively a lateral view and a cross-sectional view of the light-guiding light source 3 mentioned above. Referring to Fig. 4, there are shown entrance faces 4; a light guiding portion 5 for guiding the light, entered from the entrance faces 4, in the longitudinal direction of the light-guiding light source 3; a reflecting portion 6 for diffusing and reflecting the light, guided through the guiding portion 5, toward the original image; and a condensing portion 7 for condensing the light reflected from the reflecting portion 6 in a portion to be read of the original image. LED substrates 41, 42 are mounted on the entrance faces 4 at both ends of the light-guiding light source 3 and are provided with LED packages 81 to 83 incorporating LED chips 31 to 33.

Referring to Fig. 5, broken-lined rectangles indicate the positions of the LED packages 81 to 83 on the LED substrates 41, 42. The entire configuration is so designed that the light emitted from the LED chips

31 to 33 of the LED packages 81 to 83 does not directly enter the reflecting portion 6 provided in the lower part of the light-guiding light source 3, and that the light from the LEDs is totally reflected at both ends in the transversal direction of the light guiding portion 5, whereby the light repeat internal reflection inside the light-guiding light source 3, thereby being guided in the longitudinal direction of the light guiding portion 5 with very limited loss of the light amount.

Upon entry into the reflecting portion 6 after repeated internal reflections, the light is diffused and reflected toward the original image, then is condensed by the condensing portion 7 and illuminates only the vicinity of the reading area of the original image. The illumination intensity has good uniformity on the original image since the light beam entering the reflecting portion 6 in this state is indirect light that has been reflected in the interior of the light-guiding light source 3, and also since the aperture is adjusted in the longitudinal direction.

Figs. 6A and 6B show an example of the arrangement of the LED packages 81 to 83 on the LED substrates 41, 42 and of the LED chips 31 to 33 in the LED packages 81 to 83, wherein an LED chip is incorporated in each of the LED packages. Each LED substrate is provided with one LED chip each of R, G and B colors. The lights

emitted by the LED chips are not limited to R, G and B colors but can be of other colors such as yellow, cyan and magenta.

In Figs. 6A and 6B, the LED chips 31, 32, 33 respectively emit lights of R, G and B colors. On these LED substrates 41, 42 the LED chips 31 to 33 can be turned on and off independently for the R, G and B colors.

Fig. 7 shows the configuration of a system in which an image reading device 110, incorporating the above-explained color image sensor 200, is connected to a personal computer 130. There are provided a CPU 112 for controlling the entire image reading device 110; a color image sensor 200 consisting of the light source, the CCD line sensor etc. explained in the foregoing for converting the original image into image signals; and an analog signal processing circuit 116 for applying an analog process such as gain adjustment on the analog image signal output from the color image sensor 200.

There are further provided an A/D converter 118 for converting the output signal of the analog signal processing circuit 116 into digital signals; an image processing circuit 120 for applying, utilizing a memory 122, image processing such as shading correction, gamma conversion and magnification change on the output data of the A/D converter 118; and an interface 124 for externally output the digital image data processed by

the image processing circuit 120. The interface 124 adopts a standard commonly employed in the personal computers, such as SCSI or Bi-Centronics, and is connected to the personal computer 130.

The personal computer 130 is provided with a magnetooptical disk drive or a floppy disk drive, as an external or auxiliary storage device 132. There are also shown a display 134 for displaying the works executed on the personal computer 130, a mouse/keyboard 134 for entering commands into the personal computer, and an interface 135 for exchanging various data, commands and status information of the image reading device, between the personal computer and the image reading device.

The personal computer 130 is so designed that a color/monochromatic reading instruction can be entered into the image reading device from the mouse/keyboard 133. When a color/monochromatic reading instruction is entered by the mouse/keyboard 133, the CPU 136 sends a color/monochromatic reading command to the image reading device through the interface 135. Then the personal computer 130 executes light source turn-on control in the following manner, matching to the reading mode, according to a light source control program stored in a ROM 137. Such light source control program may be read from a memory medium such as a magnetooptical disk or a floppy disk loaded in the

auxiliary storage 132 and may be executed by the CPU 136.

Fig. 8 is a timing chart showing the driving pulses for the image sensor unit and the output thereof in the present embodiment, in case of reading a black-and-white original image with the light source-switched color image sensor. Also Fig. 9 shows the relationship between the allowable forward current of the LED and the turn-on duty ratio thereof.

If all the LEDs of R, G and B colors have an allowable forward current value as shown in Fig. 9, such LEDs have a turn-on duty ratio of about 33% in the color image reading mode as shown in Fig. 36, so that the allowable forward current in such case becomes about 45 mA. On the other hand, in the black-and-white image reading mode as shown in Fig. 37, the LEDs of R, G and B colors have a turn-on duty ratio of about 100%, so that the allowable forward current in such case becomes about 25 mA.

Fig. 10 shows the relationship between the LED forward current and the relative light intensity, indicating a fact that the light intensity increases with the forward current of LED. In case of the color image reading, involving a tripled data amount in comparison with the black-and-white image reading, it is necessary to read the data at a high speed by maintaining the illumination intensity of the original